The Benefits of Using Mobile Agents in Distributed Environments

AHMADI-BROOGHANI, ZAHRA
Computer Engineering Department
The University of Birjand
Birjand, Iran
IRAN

Abstract: - As the internet constantly expands, the amount of available on-line information expands as well. The issue of how to efficiently find, gather, and retrieve this information has led to the research and development of systems and tools that attempt to provide a solution to this problem. These systems and tools are based on the use of mobile agents. This paper is comprised of two sections: the first section is a review of general concepts and the specifications of agents and e-commerce (as distributed environment), and also mobile agents which are special types of agents and the second section begins with the benefits of using agents with review some application, those used agents to increased efficiency and robustness, followed by important factors that enhance the functionality and performance of mobile agents.

Key-Words: Mobile Agents; E-commerce; Cooperation/communication/coordination; Efficiency; Collaborative Agent System, Distributed Environments.

1 Introduction
The birth and development of software agent technology is the product of the combination of artificial intelligence and network technologies. Agents are said to become the next generation components in software development because of its inherent structure and behavior supporting component based software Engineering [1, 2]. Agents are the autonomous programs suited within an environment, which sense the environment and acts upon it to achieve their goals [3, 4]. Because of mandatory and optional (orthogonal) properties, agents distinguished from the standard programs. The orthogonal properties provide strong notion of the agents [5, 6]. The mandatory properties are autonomy, decision making (Proactive decision making may use BDI architecture [7], temporal continuity, goal oriented and the optional properties are mobility, communicative, collaborative and learning.[8].

In this paper we would like to have briefly introduction the agent technology and discussed how agent technology improves efficiency in distributed environments, to illustrate the applications, we classified gent based technologies into two types single-agent and multi-agent.

2 What is an agent?
It’s difficult to find a succinct definition for agent that includes all of the things that most researchers and developers consider agents to be, and excludes all of things they aren’t. Agents typically possess several (or all) of the following characteristics they are:

Reactive: responds in a timely fashion to changes in the environment
Autonomous: exercises control over its own actions
Goal-oriented: does not simply act in response to the environment
Temporally continuous: is a continuously running process
Communicative: communicates with other agents, perhaps including people
Learning: changes its behavior based on its previous experience
Mobile: able to transport itself from one machine to another
Flexible: actions are not scripted
Character: believable "personality" and emotional state.

2.1 Kinds of agents:
It often makes sense to qualify agents in some way. The following is not a complete list of agent kinds and there are gray areas in each kind (that is, these are not precise operational or prescriptive definitions) [some kinds courtesy of Jeff Bradshaw, Boeing]:

intelligent agent - agent that may contain introspection, planners, schedulers, rules, etc. Some kinds of intelligent agents are:
**learning agent** - agent that has adaptive behavior based usually on pattern recognition or reinforcement learning.

**intentional agent** - agent that uses speech-act-based communication, formulates plans in pursuit of its own agenda, and uses reflective reasoning.

**social agent** - agent that is capable of sophisticated coordination and reasoning about other agents (joint intentions) in teams or ensembles, agents with personalities.

**mobile agent** - agent that can move, in some cases to model a problem involving moving real-world entities or to follow a mobile user. In many cases, mobile agents are really mobile objects.

**information agent** - standalone or MAS collection of agents that collect information from multiple often heterogeneous sources and forward information to possibly multiple sources. May use channels or streams.

**user interface agent** - agent that are intended to communicate with people, either stand alone agents like chatbots or frameworks of agents like SRI multimodal map where one adds gesture or NL agents a framework to add new UI interactions.

**reactive agents or actors** - Each agent has its own thread(s) of control and responds to events and messages. Messaging is asynchronous. Agents that can react to messages or events in real time.

**middle agent** More narrowly, through the use of middle agents (matchmakers, brokers, etc.), agents can discover one another at runtime based on their capabilities, forming potentially novel teams to tackle a specific task. [from Brian Kettler, ISX]

### 2.2 Agent classification:

Agents may be classified according to the subset of these properties (the characteristics mentioned earlier) that they enjoy, or we might classify software agents according to the tasks they perform. Or, we might classify them according to their control architecture. Agents may also be classified by the range and sensitivity of their senses, or by the range and effectiveness of their actions, or how much internal state they possess. [9, 10]

There are, of course, other possible classifying schemas for example; agent technology may be classified as single-agent and multi-agent.

The agents in static agents based MAS are distributed in an environment to perform distributed problem solving, which coordinate with each other to solve a given task [11]. Mobile agents are a class of agents whose predominant feature is the ability to transport between nodes on a network or between nodes across networks. They are the basis upon which true distributed information management agents can be built. Mobile (or transportable) agents are a direct extension of the client/server technology. Mobile agents carry with them the program, data and execution state information to specified locations to complete its task. In mobile agent paradigm, by migrating to a location of a needed resource/service, an agent can interact with resource/service without transmitting any intermediate data across the network, significantly reducing bandwidth consumption in many applications (such as user customized information retrieval) [11].

Communication among the agents is an important issue in MAS environment [12].

In general, there are several benefits or good reasons for using mobile agents in MAS [13,14], reduces network load; overcomes latency; encapsulates protocols; execute asynchronously and autonomously; adapt dynamically, etc. An agent is a computer program that provides assistance to a user dealing with a particular computer application [15].

#### 2.2.1 Applications of single-agent systems

Agents can provide some of the value-added services that may form part of the package of information services, when to perform different kinds of tasks as they communicate with their user or resources [16].

We use the search agent application to illustrate the usage of single agent system:

**Search engines:** collect information available in a network, indexes them, and retrieves information based on the given queries by user/agent. The search agent initially learns about the queries made and the files retrieved by the user. Later, the agent itself frames queries on behalf of user and presents the relevant information from the user. There are some other single-agent systems applications like personal assistants, scheduling meetings, information retrieval and filtering, mail management, news filtering agent, search agents, etc.

#### 2.2.2 Applications of multi-agent systems

A MA(mobile agent) system may be viewed as a specific type of multi-agent system that would be classed as a “Heterogeneous Communicating Multi-agent System” according to Stone’s taxonomy[17]. SWARM [18, 19] and REPAST[20]
are examples of multi-agent system that are particularly popular for economic simulations. MAS based on static agents are used in wide variety of applications, such as distributed vehicle monitoring, computer integrated manufacturing, natural language parsing, telecommunications and network management, aircraft maintenance, military logistics planning, simulation of real world, satellite image dissemination, visitors communication system, etc. [21, 22]. Some of the applications of mobile agents based MAS other than telecommunications are: personal assistance, information dissemination, parallel processing, grid computing, workflow and groupware management, distributed information retrieval and data management, data mining, E-business (E-commerce), and space exploration. [22-28]. Some other applications of multi-agent applications are visitor hosting communication system, network management.

3 E-Commerce Definition
E-Commerce (electronic commerce) is the buying and selling of goods and services on the Internet, especially the World Wide Web. E-commerce refers to all forms of business activities conducted across the internet. This can include E-tailing, B2B, intranets and extranets, online advertising, and simply online presences of any form that are used for some type of communication (customer service for example).

3.1 Role of Mobile Agents in E-commerce
Mobile agents can be viewed as a combination product of software agent technology and distributed computing technology. It differs substantially from the traditional network computing model. That is because mobile agents can move continuously from one node to another, and travels based on its own needs and choices. Mobile agents can move in between the client and the server bi-directionally. Even though the architectures of mobile agent systems differ, almost all mobile agent systems contain a Mobile Agent (MA) and a Mobile Agent Environment (MAE). MAE creates a secure and appropriate execution environment for MA. In general, MAE should comprise the following basic services:

- **Business service**: Performs mobile agent creation, migration, and endurance and execution environment distribution.
- **Event service**: Implements agent transfer protocol and communication protocol and supports events transmission among agents.
- **Directory service**: Maintains status information about the location of a mobile agents and a message router that uses the directory service to deliver messages to a mobile agents.
- **Security service**: Provides a safe execution environment.
- **Application Service**: Provides service interface for specific tasks.

Agent Transfer Protocol (ATP) is employed in MAE for the migration of MAs among computers, and provides the execution environment and service interface. Agent Communication Language (ACL) is exploited by MA in MAE to communicate with various services provided by MAE.

Mobile agents have distributed characteristics. In the mobile agent computing model, the computing process and the corresponding states of the receiving computer represent completely all the requests from sender, therefore, the reliability of network is no longer that important because:

- Mobile agents doesn't require a lot of bandwidth, only what's needed during migration.
- Mobile agents continues to execute after migration, even if the connection to the initiator is lost.

Therefore, if a client needs a lot of communications with a specific server in the network, the best way to achieve it is to employ mobile agent system. An agent can travel autonomously to a remote server, execute the computation and return to the client. The MA paradigm can be used to test E-commerce environments as well as examine electronic market behaviors [29].

4 Benefits of using agents
However, a fundamental problem exists with client/server architectures when considering distributed information system. The mobile agent paradigm attempts to address the issues that are raised by the client/server and paradigms. Typical characteristics of mobile agents are their ability to migrate at will, autonomy in their actions, a peer-to-peer personality and a processing and network independence from their original location. **Mobility is a desirable characteristic in agents for a number of reasons**

- **Efficiency**: If an agent can move across networks to the location where resources reside, then network traffic can be reduced since
(crucial aspect when connect through a low bandwidth link).

- **Persistence.** Once a mobile agent is launched, it should not be reliant on the system that launched it and should not be affected if that node fails (This is useful for mobile computer users due to the fact that they can log on, launch an agent, log off and check later on its progress).

- **Peer-to-peer communication.** A failure of the client/server paradigm is the inability of servers to communicate. Mobile agents are considered to be peer entities and, as such, can adopt whichever stance is most appropriate to their current needs (This allows for great flexibility in dealing with network entities and distributed resources).

**Adaptability:**
The mobile agents enable the proxy to adapt to the estimated network delays and prepare the presentation schedule as per the presentation category of the user. The E-shopping server adapts to the changes in network and server resources by planning different types of presentations according to the user behavior.

**Collaboration is good.**
The reason is simple: an agent alone can only learn a limited amount each time step, while agents that share data often acquire a large amount of new information in a single interaction.

**Mobile Agents communicate together (Agents talking to agents)**
This is true because agents, by themselves, aren't very powerful. It's only by working together with other agents that they become useful. Communication is the backbone of organization. The reason communication is so important is that it allows individuals to organize into groups with a shared purpose and to operate much more efficiently. An organization is much more (and more effective) than the sum of the individual parts.

**Agents learn**
Developing agents, which are able to learn from each task so next time the same agent knows the ways for fetching the same information or using the same reliable platforms in internet, or develop certain degree of reasoning to take intelligent decisions/actions will improve the efficiency of the system. Learning mechanisms could be based on reinforcement learning, neural networks, training by examples and genetic algorithms.

**Intelligent Mobility**
An effective implementation of intelligent mobility allows an agent to avoid slower communication links and processors, and react to communication failures by choosing an alternative host or execution path. The work Ref [30] used the intelligent mobility concept as a means for agents to improve execution efficiency and exploit alternatives in case of resource unavailability.

**The agents operate asynchronously**
They do not need permanent connections between a source and destination. This facilitates the source to carry on some other tasks instead of waiting for the sent agent. Thus, an agent sent across the network will travel on its own and report back its round trip delay to the source. This feature is especially more useful in case of wireless networks where frequent disconnections are possible.

The work given in Ref [31] implies to benefits of using agents in product information presentation in e-commerce.

**Flexible**
Advanced telecommunication services are characterized by dynamic network reconfiguration and user customization. The physical size of these networks and the strict requirements (under which the services operate) call for agent technology to keep the systems flexible and effective. The works in Refs [27,28] describes about the software agents for telecommunications network management and service provisioning in Public Switched Telephone Network (PSTN). It allows dynamic downloading of customized services at end-users and the service control points of a network.

**Autonomy**
Agents in tactical networks must robustly react to inevitable machine failures. The work in Ref. [30] describes how using autonomous agents improves efficiency and robustness in slow, unreliable networks. EMAA agents contain hooks for reaction policies to be executed in special situations including migration, remotely initiated halt, or catastrophic errors that inhibit execution of the itinerary. Each EMAA agent operates within its own thread, so a single failure poses no threat to other independent agents or interacting systems.

5  **Factors which increase the efficiency of the mobile agents**
The important factors which increase the efficiency and enhance the functionality of the mobile agents are:

**The numbers of server dose an agent know**
This factor increase the capability of the agent to journey from one server to another till the job is done.
The Agent must be configured with as many as possible server addresses, where it can reside on, collect information or do other jobs.

**Using a common database:**
It is also possible to have a central database, which is updated by the agents so they will firstly try to get information from this database each time they get a new Task (e.g. looking for cheapest last minute product). If there isn't any Information which an agent currently looking for, or the database doesn't have enough information about the agent's new task, then the agent should search in internet and update the database server with the current information.

**Which programming language is the agent developed in?**
This is important, if the agent have to do some time and performance critical tasks.

With using a fast programming language and Choosing a programming language that match the needs and is compatible with as many as possible agent-platforms (servers, desktop clients (PC-Programs, etc.) is possible to increase the agent's efficiency.

**Agents learn**
Developing agents, which are able to learn from each task so next time the same agent knows the ways for fetching the same information or using the same reliable platforms in internet.

**Using multiple Agents**
The Client (could be a Server or a customer's machine) generates and sends several agents into the internet for searching and gathering information about one or several products.

**Configuration of Agents**
The Client may give the agents some initial information for example:
- Where the agents should looking for the information.
- How many information should be fetched before the agents finish their job?
- An agent could terminate itself, if it wasn't able to complete the job within a defined deadline.
- An agents may clone itself, if for example the collected information were too much.
- The information could be shared with other agents or even sent to the client machine etc.

**Programming logic (business logic) on which the agent based on**
This Determine, the capability of the agent to choice better rules to do the job.

**Increasing performance by cloning agents** A mobile agent may CLONE itself, if it notices a deficiency because of one or several of the following reasons:
- The server(s) which the agent reside on, is (are) not performance enough, so the agent could not finish the job before the defined deadline.
- The information's that an agent must collect become greater than a defined size
- The agent need information's from other servers but itself has to reside on the same server.
- A journey from one server to other gets to long, because of the low bandwidth between the servers.
- Many of friendly agents aren't available so the agent could assume that they were deleted, corrupted etc.

**6 Conclusion**
The paper introduced the agent technology concepts, and then presented number of applications of agent technology in communications. It introduced the role of mobile agents in E-commerce, and the benefits of using agent were discussed and finally the important factors which increase the efficiency of agents were presented.

Agent based schemes comprising of static or mobile agents offer several advantages, such as, flexibility, adaptability, software reuse and maintainability, and thus improves overall performance of the systems (which use agents) as compared to traditional methods.

Using mobile agents represents an important lead in the development of first generation (static) agent systems. The possibility of working offline thus saving network resources is one of the main advantages, Other advantages are:
- They overcome network latency
- They encapsulate protocols
- They execute asynchronously and autonomously
- They adapt dynamically and react autonomously to changes
- They are naturally heterogeneous, providing optimal conditions for seamless system integration
- They are robust and fault tolerant,…

There are some factors which increase the efficiency and enhance functionality of mobile agents as discussed in the paper, however there is long list of problems related to the way mobile agent technology is being perceived and implemented. Hence there is need to improve the practice of agent technology.
References: